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SCIENCE AND THE GOVERNMENT.

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It has sometimes been said that no other Government has so large and able a body of scientific experts in its employ as ours. To discuss in an exhaustive way the correctness of this statement would require a careful study of the systems adopted by other countries, especially France and Germany, in the administration of their public works. We should be met at the outset by the question whether the graduates of the Government technical schools of France and the men employed in Germany on public works of various kinds are to be included in the comparison. Whatever conclusion we might reach on this point, it may be conceded that no Government is more alive than our own to the public advantages which accrue from the applications of science to the arts of life, or has adopted a broader and wiser policy in promoting such applications.

Granting all this, there is a converse proposition on which it is not easy to reach an equally satisfactory conclusion. Notwithstanding the liberality of our policy in promoting scientific research, there is no Government less alive than our own to the advantages which it might derive from the advice and assistance of that large body of scientific experts who are not in Government employ. We fail to recognize the fact that questions of great practical importance are continually arising which cannot be dealt with in the most satisfactory way by the organized machinery of a Government bureau.

Our failure in this respect can be best seen by contrasting it with a class of cases in which nothing can be said against our wisdom in dealing with them. From time to time important questions of public and international law arise in which the best legal talent that the Government can command is necessary to the protection of its interests. In such cases we never hesitate to go outside the public service and call for assistance upon the

ablest jurists of the country. We no more than any other Government would have thought of conducting our cases before courts of arbitration without calling in some addition to the ordinary machinery of our Department of Justice.

The same exigency arises in the application of scientific method to the administration of those great public works which the development of our country constantly imposes upon the general Government. Here is required, from time to time, a knowledge of details which we cannot always expect to be at the command of a Government officer, no matter what may be his qualifications. The question then arises, where and how we shall obtain the results of the widest knowledge and the latest researches.

The reasons why the knowledge and experience of a Government officer are not always adequate to the problems which may come before him are obvious. Whatever his abilities, he is in some sort a subordinate, and the general ideas of discipline inseparable from the public service impede his action and prevent his full responsibility from being publicly recognized. He always has a chief who, in the eye of the law, is the really responsible head to whom the Executive and Congress look for authoritative views. As a general rule the scientific official is nearly, or quite, unknown as an exponent of those views. His proper functions are to do what he is told, to apply his experience to the case before him, and to give his chief the benefit of his attainments. If his opinions happen, for the moment, to be opposed to the popular view, he may get himself or his chief into difficulty by trying to give them effect. The larger the measure of worldly wisdom with which nature has endowed him, the feebler will be his attempts to become a factor in directing the policy of the department with which he is connected. In any case, his studies are likely to be confined to the limited field embraced in the round of his official duties; and thus it may happen that, how great soever his influence, he will not always be the best counsellor on questions lying outside the routine of those duties. Such being the case, why should not the Government call upon the best scientific talent of the country for advice and assistance just as it calls upon the best legal talent when need arises for it?

One answer is not far to seek. The men of the highest judicial

talent are publicly well known and easy to reach. No one in authority has any serious difficulty in learning who they are. But the public knows little of the standing of professors in the scientific world, or of the nature of the questions with which they are conversant. The result is that, if the system of calling in such men were adopted, any professor of chemistry of sufficiently good address, especially one who was accustomed to appearing before courts of law as an expert, might be called in as the best chemist, and any fine old gentleman who had published a brilliant essay on a new theory of the universe might be selected as an astronomer. In this respect other Governments are probably no better off than our own. It is said that some fifty years ago the British Admiralty had printed a few copies of an important work for presentation to some foreigners who, from their prominence in the scientific world, were best entitled to be honored with the gift. Professor Airy, the Astronomer Royal, was requested to make a selection of the names. A few days after he had sent in his list he was informed by the Secretary of the Admiralty that "my lords" were struck by the number of unknown names included; and that they wished to make an inquiry on the subject. Airy asked the Secretary for some specifications as to the names referred to.

"Well, as an example," said the Secretary, "here is the name of Professor C. F. Gauss, of Göttingen. Who is he?"

"Gauss is one of the greatest mathematicians of the age, and stands among the two or three most eminent masters in physical astronomy now living. Who else do you wish to know about?"

"No one else; that will do," replied the Secretary.

It is the principal object of the present paper to show that this difficulty, formidable though it may appear at a distance, vanishes when we come to grapple with it. In every civilized country there are organized bodies of men of science and learning, at least one of which is recognized as having a national character. The importance which has been played by these bodies in the progress of the age cannot be overestimated. Modern science, properly so called, commenced with the foundation of the Academy of Sciences of France by Colbert, and the charter of the Royal Society of London by King Charles II. In the beginning the organizers of these societies had no distinctly utilitarian end in view. They were moved only by an enlightened appre-

ciation of the lustre that would be thrown upon their respective countries by the progress of science and learning. We cannot suppose that they had any anticipation of what the measures they adopted would lead to in future generations. The benefits of attrition between men of like and yet slightly diverse minds were doubtless appreciated, but could not have been estimated at their full value. As we may trace back a race of animals to its progenitors, so may we trace all our applications of electricity and heat to the men who, in France, England and Italy, came together for mutual help and sympathy in the study of nature during the seventeenth and eighteenth centuries.

From the beginning these men were animated by an *esprit de corps* of which the world at large has taken little account, but which has been an important factor in the result. One who by long and patient study discovers truths that seem to him interesting and important, is naturally desirous of making them known to his fellow-men without respect to any personal advantage that might accrue to himself. Disinterestedness of motive has been the pivot on which the policy of the bodies in question has very generally turned. In the beginning the French Academy adopted a regulation prohibiting its members from using for their personal advantages discoveries made with the co-operation of the Academy. Although other societies have not gone so far as this, their general policy has wisely been directed to the general enlightenment of mankind and the promotion of its best interests, rather than to that of the personal interests of its members.

One of the most striking features of this spirit during the two centuries in question has been the separation of the functions of the investigator and discoverer from those of the inventor. The Galileos, Newtons, Herschels and Faradays of science; the men but for whom the nineteenth century would have been like the eighteenth, and that, like the seventeenth, did not reap or attempt to reap any pecuniary advantage from their works. While they may not have gone so far as the eminent mathematician who is said to have thanked Heaven that he cultivated a science that could not be prostituted to any useful purpose, it is certain that they were quite willing to leave to others the functions of determining in what way their discoveries could be applied to practical ends. This policy was essential to the highest success of their work. If they had not been guided by it; if they had always

been on the alert for discovering something admitting of practical application, their work would have been wanting in that breadth and fulness which was necessary to its ultimate usefulness. Many a pearl now of great price would have been thrown into the dust heap because the finder would not have seen its value. What prospect could Volta and Galvani have seen of benefits being derived from their experiments on the movements of the legs of a frog when certain metals were brought into contact with the muscles of these animals?

In pointing out the value of the work of the investigator we by no means belittle the functions of the inventor. The world justly holds in honorable remembrance the names of the men who have applied to practical uses the discoveries made by the investigators. Their functions were clearly necessary to the result. The pecuniary rewards which they reaped were so small when compared with the good they have done that a mathematician might rank them among the infinitesimal quantities. Yet, we should not forget that the Watts, the Stephensons and the Morses never made any addition to our knowledge of the laws of heat, steam or electricity. What they did was to take the knowledge gained by others and apply it to practical uses. We cannot say that they have got more than their due share of public credit, but we may fairly say that the public has not always been sufficiently alive to the very different functions of the class of men who form the scientific academies and societies of the world.

It is perhaps from a consciousness of the distinction between these two classes that the world has always refused to award its highest appreciation to mere utility. Witness the very different estimation in which we hold the useful negro and the useless Indian. The sentiment of reverence for pure philosophy was even stronger in early ages than at the present time. The contempt of the ancient philosophers for useful applications of knowledge was none too strongly expressed by the sentiment of the mathematician whom we have quoted. The encouragement given to men of science and learning by the founders of the national scientific societies of Europe was based much more upon a consciousness of the honor that they would do to their respective countries than on any hope of useful results from their labors. At the same time it was evident that these men might be of great benefit to the State. The latter had from time to time

serious need of broader views than those commonly taken by professional inventors. And thus Governments fell into the habit of consulting the members of their academies, either individually or collectively, on all questions in which their knowledge would be of benefit to the State.

One object of the present paper is to review what our Government has done in this direction. Its course has not been marked by any lack of appreciation either of the practical or æsthetic value of scientific research. Its policy in supporting scientific bureaus and promoting their work has perhaps been broader and more liberal than that of any other Government. It has never counted the mere dollars and cents of income and outgo in estimating the value of knowledge. It has clearly seen that possible permanent benefits to future generations, the value of which could not be estimated at the present time, must be taken into consideration.

What it has wanted is a knowledge of the best method of promoting the application of scientific principles to public works. It has relied too much upon its own officers and employees, and does not appreciate the advantages to be derived from associations like the Paris Academy and Royal Society of London. Abstractly every one knows that the question whether a ship shall be safely navigated to her port or be cast away on the rocks may turn upon the presence or absence of a very little knowledge on the part of her captain. But the public does not perceive that the same thing is true at every step which we take in the development of our resources. Cases are frequently arising in which the ordinary routine of Government work cannot be relied upon to secure the best results.

A single illustration from contemporary history will show what I mean better than generalities. In 1882 Congress made an appropriation for improving the water supply of Washington by extending an aqueduct under the city. It entrusted the entire work to its officers. The latter knew that under the soil on which the city was erected there existed a layer of solid rock, of sufficient hardness and consistency to serve for the walls of the proposed aqueduct. Accordingly the latter was hewn at a great depth through the rock and carried to a reservoir several miles away.

Nothing could be said against the professional capacity of the

engineers who conceived and executed this plan. They carried on the work with that economy and on those sound business principles which characterize the operations of our Government engineers. They knew everything that an engineer could reasonably be expected to know. Yet they did not know that the rock through which they were hewing their aqueduct, firm though it appeared on inspection, would ultimately disintegrate under the action of water. The inevitable result would be that, in a few months or a few years, the rock in which the aqueduct was cut would be reduced to a mass of sand.

Had the Government been in the habit of consulting scientific experts who were not professional engineers, on every question of science that might arise, this knowledge would have been gained before the aqueduct was projected. The liability of some hard and solid rocks to disintegrate is well known to geologists. The services of one of these men would have cost little, and a very little study would have brought out the fact that the rock in question was of this class. For want of this study a large sum, perhaps a million of dollars or more, has been wasted on the work, and now, after the lapse of seventeen years, it is uncertain whether the aqueduct will ever be made use of.

We cannot say that the doings of our Government have uniformly been of this unsatisfactory character. When the Civil War burst upon us, the need of supplementing the professional attainments of Government officers by those of scientific men whose services were at command led to the formation of a scientific commission, to which various questions were from time to time referred. The organization of this commission was, we believe, somewhat informal. Indeed, we do not know to what extent it has been recognized in the history of the war. Among its members were Professor A. D. Bache, Superintendent of the Coast Survey; Professor Joseph Henry, Secretary of the Smithsonian Institution, and Rear-Admiral C. H. Davis, U. S. N., Chief of the Bureau of Navigation in the Navy Department. The usefulness of the commission suggested its being enlarged into a permanent organization similar to the academies of science of Europe. Thus arose our National Academy of Sciences, which was chartered by act of Congress in 1863. Its membership was at first limited to fifty; but the restriction of numbers was repealed by a supplementary act of Congress. The Academy was

required to hold an annual meeting at such place in the United States as might be designated, and, whenever called upon by any department of the Government, to "investigate, examine, experiment and report upon any subject of science or art." The actual expense of the work performed was to be paid by the Government, but the Academy was to receive no compensation whatever for any services thus rendered.

This body labors under the great disadvantage of having its membership scattered over the entire country instead of being concentrated at the Capital, as is the case with the national academies of Europe. It is true that in England the fellows of the Royal Society reside in every part of Great Britain; but the great bulk of the membership is found in London and its immediate neighborhood. Still, our Academy has done enough for the Government to demonstrate the great value of its services. Twice in its history it has been called into council on questions of capital importance. One of these questions concerned the surveys of the public domain; the other the proper measures to be taken for the preservation of our forests. It will take but a cursory glance at these two questions to show the weak points in our system which such a body is needed to strengthen.

Explorations of our territories, carried on by parties which may be designated as semi-official, have been undertaken through the whole period of our national history. Such enterprises were formerly directed to some particular regions, or toward the attainment of some special end, and had no permanence in their organization. The explorer completed his journey and returned home to report what he had seen and learned.

About thirty years ago surveys and explorations having a greater or less permanence of character began to be undertaken. Among these enterprises the survey of Professor F. V. Hayden soon became the best known. The head of the survey combined a respectable position in the scientific world with tireless energy and great enthusiasm. He spent his summers in work in the field and his winters in rousing Congress to a sense of the importance of what he was doing and of the desirableness of larger appropriations for his work. He was so successful in these efforts that his organization grew apace and soon developed into the Geological Survey of the Territories.

Contemporaneously with this survey grew up another, under

the War Department. The latter needed a survey specially prosecuted for military purposes. In some features it was necessarily different from a purely geological survey. At the same time it was very evident that a party executing a survey for military purposes could very easily include in its scope all the requirements for a complete geographical and geological exploration. Congress responded to an appeal on this basis, as it did to the appeals of Hayden, and thus arose the Geographical Survey of the Territories, which was carried on by the Chief of Engineers of the Army, under the personal direction of Lieutenant Wheeler.

Besides these two permanent surveys, others somewhat temporary in character were executed. One was that of Clarence King, which was confined to the region near the fortieth parallel. Another was that of Major J. W. Powell, which was specially devoted to the great Cañon of the Colorado. The field work of this survey was speedily completed, but the preparation and publication of the results extended through several years.

Leaving out of consideration these more or less temporary enterprises, we had the curious spectacle of the Government supporting two independent surveys of the same region for almost the same purpose, neither of which had any official knowledge of the work of the other. Both were vigorously engaged in making a map of Colorado; both mapped down the lines of communication, the one for military purposes, the other for civil purposes. We can hardly suppose that there was any great and essential difference between the two. Both had the requirements of agriculture and the investigation of the mineral resources in view. The two parties sometimes mounted their theodolites on the same mountains, triangulated the same regions, came to Washington in the winter, prepared maps showing the progress of their work in the same region, and submitted them to Congress in support of increased grants of money. The Hayden Survey finally had the pleasure of publishing a complete atlas of Colorado, and the Wheeler Survey of issuing a number of maps of the same territory about the same time. Both were proceeding with undiminished vigor to extend their work over other territories.

It would not be just to say that this state of things illustrated the incapacity of Congress to deal with a disputed administrative question. We cannot suppose that Congress failed to see the difficulty and was not fully capable of grappling with it. What it

really illustrates is the repugnance of Congress to the adoption of decisive measures of any sort for the settlement of a disputed administrative question. Infant bureaus are its infant children. They may quarrel with each other and eat up the paternal substance; but the parent cannot make up his mind to starve them outright. They must be fed and nurtured with the hope that, at some time in the distant future, they will grow so wise as to live together in harmony.

But in the present case, as the years passed away, there was no prospect of such a happy consummation, even in the remote future. Both surveys were determined to carry through their entire work. The one unofficially reviled the political methods of the other; the latter retorted with equally unofficial reflections on the scientific incapacity of its rival. If one showed finer maps, the other showed how economical it was to get up a less artistic map.

Various attempts were made to devise some plan of reconciliation or some system by which the two surveys should not duplicate each other's work. But it does not seem that anything came of these efforts. Then it was that Mr. A. S. Hewitt, of New York, a member of the Committee on Appropriations, be-thought himself that the Government had at its command a body which could deal with the question in an intelligent way, without being affected by parental sympathy for either infant. This was the National Academy of Sciences. The committee accepted his view, and, in accordance therewith, a clause was inserted in the Sundry Civil Bill of June 30, 1878, requiring the Academy at its next meeting to take the matter into consideration, and "report to Congress as soon thereafter as may be practicable, a plan for surveying and mapping the territory of the United States on such general system as will, in their judgment, secure the best results at the least possible cost."

Several of the older and more conservative members of the Academy held that the proposed report did not come within the proper sphere of that body. The question of a plan for surveying the territories of the United States, it was claimed, was not one of either literature, science or art, but of public administration, which it was the duty of Congress to deal with. Referring such a question to the Academy was drawing the latter into the arena of political discussion to an extent that would be detri-

mental to its future standing and usefulness. But it was quite evident, on the other hand, that the Academy, a creature of Congress, could not well join issue with the latter on the question of its proper functions. Moreover, an opportunity of rendering a great service to the Government should not be lost for so slight a reason. The membership included not only men connected with both surveys, but many others acquainted with every aspect of the case, and able to take a broad view of the whole question.

As might have been expected under the circumstances, the report of the committee was radical, drastic and comprehensive. All the work of surveying and mapping the territories was considered as a whole; and it was to be prosecuted under a single department. The co-operating bureaus would thus be placed in close communication with each other, and their proper limits defined by superior authority. The interior work of the Coast and Geodetic Survey, the Geological and Geographical Survey of the Territories, the surveys of the Land Office, and the preparation of maps of the whole region were all to be carried out as parts of one and the same general plan.

Such a proposal was too radical to receive the immediate and unqualified assent of Congress. The most powerful and active opposition came from the Surveyors-General of the Land Office, who succeeded in having their own department dropped from the scheme. The Coast and Geodetic Survey, while raising no strong objection to the change, did not actively favor it. From a purely official point of view the army survey made the most vigorous fight against extinction. But it was unsuccessful, and the two rival surveys were both wiped out and replaced by the Geological Survey of the public domain.

If the success of an organization is to be measured by the amount of public support which it has received; by the constant extension of its work and influence, and by the gradual dying out of all opposition, then must the plan be considered a brilliant success. In this connection it must be remarked that the Academy is in no way responsible for the extension of the Geological Survey into the States. Its plan was in terms limited to the national domain. The membership of the Academy was so cautious and conservative that it may well be doubted whether a plan for extending the survey into the States would have met with its approval. Whatever view we may entertain on this question, it

is certain that the extension by Congress, on its own motion, of the plan devised by the Academy cannot be regarded as anything but a compliment to the work of this body.

A question of even greater importance than that of surveying the public domain is that of the administration of the forest land under control of the general Government. Our forest administration is principally under control of the Interior Department. Heads of that department have long met with insuperable difficulty in protecting the public interests vested in the forests against the encroachment of private parties. Mining companies, ostensibly cutting timber for their use, were really lumber companies selling it for their own private purposes. Pretended settlers entitled to the use of the timber were really the agents of corporations. Regulations for the protection of the forests against depredation were found incapable of enforcement. These depredations increased with the growth of population, until, a few years ago, we were confronted with the prospect of the entire destruction of all the timber worth cutting from the public lands.

In 1896 Secretary Hoke Smith called upon the National Academy of Sciences for a report on the subject. In his letter to the President of the Academy he said :

“My predecessors in office for the last twenty years have vainly called attention to the inadequacy and confusion of existing laws relating to the public timber lands and consequent absence of an intelligent policy in their administration, resulting in such conditions as may, if not speedily stopped, prevent a proper development of a large portion of our country ; and because the evil grows more and more as the years go by, I am impelled to emphasize the importance of the question by calling upon you for the opinion and advice of that body of scientists which is officially empowered to act in such cases as this.”

The Academy commission devoted more than a year to an extensive investigation of the whole subject. Its report included not only a study of the conditions in our own country, but of the policies adopted by foreign countries, especially Germany, and their results. But no sooner did Congress begin to act on the report by enacting the legislation recommended in it, than its conclusions were violently attacked. Such a result was both right and natural. For the same reason that the Anglo-Saxon race find it wise that the conclusions of one legislative body should

be independently examined and reviewed by a second, it is always fitting that any proposals on so complicated a question as this should be put to the test of the closest examination and criticism before being accepted. The question whether the criticisms originated with men who were profiting by the lax system in vogue might well arise, but need not be considered.

In the discussion which followed, the interests of the public were at a disadvantage. The assailants wielded great political power in their respective States. They had against them only the moral force behind a report made by men of the highest authority, who had no personal end in view. For a time it seemed as if they would be successful and the Academy would suffer rather than gain in the opinion of the Government by the report it had made. But the moral force behind the report was such that, in the long run, some of the severest critics saw their error, and the most essential features of the plan were carried into effect by legislation and executive action. The Interior Department, the Geological Survey and the Department of Agriculture are all prosecuting different branches of the work with harmony and success, a consummation in strong contrast with the state of things which formerly prevailed.

The need of such expert knowledge as can be supplied by men who are foremost in every branch of research is one that must constantly grow with the complexity of the problems that face our Government. The problems associated with the initiation of new public works, especially those which involve the application of some new principle, the administration of the national domain, irrigation and the public health are examples. The smallness of the money cost of such knowledge is perhaps one reason why its importance is overlooked. We naturally are inclined to measure value by cost. It would not be surprising if the sums expended a few years ago in bombarding the sky to bring down rain should far exceed the annual average cost of all the expert assistance the Government would ever need for a generation to come.

SIMON NEWCOMB.